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(54) Title: IMPROVED ALLOY FOR CAST COMPONENTS

(57) Abstract

Alloy and cast alloy product ideally suited for use as a component, for example, in a vehicle frame or subframe, i.e., a body-in-white, comprising an alloy comprising about 0.15 to .35 wt.% magnesium, and about 8.50 to 11.00 wt.% sillicon, and about 0.40 to 0.80 wt.% manganese, and, with preferably less than 0.50 wt.% iron, the balance substantially aluminum and incidental elements and impurities, such as strontium, sodium, and antimony for modification of the silicon morphology. The alloy is typically solidified into ingot derived working stock by continuous casting or semin-continuous casting into a shape suitable for remelt for casting, which shape is typically an ingot billet. This alloy demonstrates reduced die erosion, notwithstanding its low iron content.

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IMPROVED ALLOY FOR CAST COMPONENTS

This invention provides improved low iron content, aluminum casting alloys. In particular, the aluminum/silicon casting alloys of this invention are adapted to reduce die tooling chemical erosion that is typical for low iron content alloys.

It is known to manufacture a vehicle frame by providing separate subassemblies, each subassembly being composed of several separate components. Each subassembly is manufactured by joining together several tube-type members with tube and socket joint or by means of a node structure that can be a cast component. The frames and subframes can be assembled by adhesive or other bonding or by combinations of these and other joining techniques. An example of such a vehicle frame structure is available in United States Patent No. 4,618,163, entitled "Automotive Chassis". Aluminum is a highly desirable metal for such vehicle frame constructions because of its reduced weight compared to the steel typically used for such components. Aluminum alloys also demonstrate good strength properties and improve the vehicle frame's stiffness. More importantly, an aluminum vehicle frame demonstrates the strength and crash worthiness typically associated with much heavier, conventional steel frame vehicle designs. The lightweight aluminum vehicle frame also provides numerous environmental benefits and efficiencies through reduced fuel consumption and the opportunity to ultimately recycle the aluminum frame when the useful

life of the vehicle is spent.

A preferred method of producing the aforedescribed aluminum cast components is die casting, particularly, vacuum die casting, as described in applicant's U.S. Patent No. 5,076,344 entitled "Die Casting Process and Equipment." Many aluminum die casting alloys encounter some drawbacks during die casting operations. Some drawbacks are found, for example, in the aggressive interaction of the molten aluminum alloy and the steel die surface that results in two types of damage to the die tooling. One type is the physical erosion of the die that results from the flow and impingement of high velocity molten metal within the die casting machine. The other type is the chemical dissolution that takes place at the surface of the die tooling and other components of the die casting machine due to chemical interaction between the steel and the molten aluminum casting alloy. It is known to treat the surface of the steel components to retard the physical erosion and chemical dissolution described above. However, even with the use of a surface treatment, both physical erosion and chemical dissolution remain problematic. Chemical dissolution of the die surface is typically minimized by the use of higher iron content in the aluminum casting alloy. Typically, when the iron content is above 0.60 wt. %, die erosion caused by chemical dissolution is minimized. Unfortunately, a higher content of iron in the alloy has an adverse effect on the mechanical properties and elongation required for the type of structural applications associated with automotive components. It is to be appreciated that alloy composition does not address the independent limitation to die life caused by physical erosion from the flow of molten metal. Physical erosion is a separate problem that is best addressed through die design modifications and improvements to casting process parameters. A

solution to the difficulties attendant physical erosion are beyond the scope of the instant invention.

This invention is concerned with: providing aluminum alloys ideally suited for use in metal mold operations, including, for example, squeeze casting and die casting operations;

providing improved, low iron content aluminum alloys that enhance die tool life in a die casting operation; and

providing improved cast products and components consisting of an improved low iron aluminum alloy cast members that ideally are suited for frames, subframes, and frame members in vehicle primary structures or secondary structures, as well as various component parts for a variety of applications, including transportation products.

According to the present invention there is provided an improved low iron aluminum alloy for casting operations, comprising about 0.10 to 0.35 wt. % magnesium, preferably about 0.15 to 0.20 wt. % magnesium, about 8.50 to 11.00 wt. % silicon, preferably about 9.5 to 10.5 wt. % silicon, about 0.40 to 0.80 wt. % manganese, preferably about 0.6 wt. % manganese, and with preferably less than 0.50 wt. % iron, the balance substantially aluminum and incidental elements and impurities.

In accordance with this invention, the alloy composition is formulated to contain about 0.10 to 0.35 wt. % magnesium, preferably about 0.15 to 0.20 wt. % magnesium, about 8.50 to 11.00 wt. % silicon, preferably about 9.5 to 10.5 wt. % silicon, about 0.40 to 0.80 wt. % manganese, preferably about 0.6 wt. % manganese, and with preferably less than 0.50 wt. % iron, the balance substantially aluminum and incidental elements and impurities, such as strontium, sodium, and antimony for modification of the silicon morphology. The alloy is typically solidified into ingot-derived

working stock by continuous casting or semi-continuous casting into a shape suitable for remelt for die or shape casting, which shape is typically an ingot billet.

In connection with the present invention, aluminum-silicon casting alloys are understood as meaning aluminum casting alloys containing silicon as the main alloying element. The concept of aluminum-silicon casting alloys consequently also implies alloys containing further alloying elements, special additions, and commercial impurities, and comprises both primary and remelted alloys. Depending on the field of application, the silicon content of aluminum - silicon die or shape casting alloys is preferably between about 8.50 and 11.00 wt. %. According to current die casting practice, upon completion of the casting operation, the cast component is quenched to cool it sufficiently to permit the trimming of the cast component in a trim die. The cast product can be subjected to heat treatment and aging in order to obtain a product that demonstrates desired properties.

The alloys of this invention are characterized by a surprisingly reduced level of the chemical dissolution that causes erosion of the die during die casting operations. To demonstrate the practice of the present invention and the advantages thereof, aluminum alloy products were made having the compositions shown in Table I. Each of these examples demonstrated the enhanced tool life described in detail below.

Table I

Example	Si	Fe	Mn	Mg	Sr	Fe & Mn
1	9.85	0.11	0.60	0.18	0.028	0.71
2	10.00	0.11	0.61	0.18	0.024	0.72
3	9.90	0.11	0.59	0.18	0.023	0.71

It is believed that the unexpected benefit of a reduced

level of erosion of the die during die casting operations is obtained due to this invention's levels of iron and magnesium compared to existing low iron alloys. The manganese is believed to provide improved die life when casting Al-Si alloys with low Fe content. For example, the surface of H13 steel plugs placed in a historically high erosion region of an ejector pulldown of a casting die is illustrative of the erosion caused by chemical dissolution that the die encounters during casting operations. Die erosion is evident by the presence of dissolution pits in the steel surface after casting 500 shots with existing low Fe alloys, i.e., low Mn levels. By comparison, after conducting casting trials with the instant invention, it was found that after more than 500 shots, no dissolution pits were present in the surface of the steel ejector plugs. In addition, it is believed that the addition of manganese in the low iron alloys of this invention substantially reduces the sticking tendency of the low Fe casting alloy in the die which is attributed to soldering. Preferably, the alloy contains approximately 0.10 to 0.50 wt. % iron and 0.40 to 0.80 wt. % manganese. Preferably, the alloy contains a total of no more than preferably 0.90 wt. % iron plus manganese. So that within the parameters set out above, as the weight percent of iron increases, the weight percent of manganese decreases, the total level of 0.90 wt. % of iron and manganese is maintained. Likewise, as the weight percent of manganese increases, the weight percent of iron decreases in order to maintain the preferred range.

By way of example, an alloy commercially available from the assignee of the instant invention and disclosed in U.S. Patent No. 5,076,344, fails to demonstrate the reduced die tooling chemical erosion that is unexpectedly obtained through the use of the instant invention. The improved performance of the

instant alloy is believed to be a function of a lower iron solubility in the Mn containing interdendritic liquid during solidification. The lower solubility in the instant alloy results in a slower chemical dissolution rate of the steel surface.

Unless indicated otherwise, the following definitions apply herein:

a. Percentages for a composition refer to % by weight.

b. The term "ingot-derived" means solidified from liquid metal by a known or subsequently developed casting process rather than through powder metallurgy techniques. This term shall include, but not be limited to, direct chill casting, electromagnetic casting, spray casting and any variations thereof.

c. In stating a numerical range or a minimum or a maximum for an element of a composition or a temperature or other process matter or any other matter herein, and apart from and in addition to the customary rules for rounding off numbers, such is intended to specifically designate and disclose each number, including each fraction and/or decimal, (i) within and between the stated minimum and maximum for a range, or (ii) at and above a stated minimum, or (iii) at and below a stated maximum. (For example, a range of 1 to 10 discloses 1.1, 1.2...1.9, 2, 2.1, 2.2...and so on, up to 10, and a range of 500 to 1000 discloses 501, 502...and so on, up to 1000, including every number and fraction or decimal therewithin, and "up to 5" discloses 0.01...0.1...1 and so on up to 5.)

Having described the presently preferred embodiments for an improved casting alloy, it is to be understood that the invention may be otherwise embodied within the scope of the appended claims.

CLAIMS

1. An improved low iron aluminum alloy for casting operations, comprising about 0.10 to .35 wt.% magnesium, about 8.50 to 11.00 wt. % silicon, about 0.40 to 0.80 wt. % manganese, and with preferably less than 0.50 wt. % iron, the balance substantially aluminum and incidental elements and impurities.

2. The improved low iron aluminum alloy according to claim 1 wherein the alloy is preferably about 0.15 to 0.20 wt. % magnesium.

3. The improved low iron aluminum alloy according to claim 1, wherein the alloy is preferably about 9.5 to 10.5 wt. % silicon.

4. The improved low iron aluminum alloy according to claim 1, wherein the alloy is preferably about 0.5 wt. % to 0.7 wt. % manganese.

5. The improved low iron aluminum alloy according to claim 1, wherein the alloy is preferably between about 0.10 to 0.50 wt.% Iron and between about 0.40 to 0.80 wt. % Manganese and the total weight percent of Fe plus Mn is no greater than approximately 0.90 wt. %.

6. The improved low iron, aluminum alloy according to claim 5, wherein the alloy is preferably about 0.10 wt. % Fe and 0.60 wt.% Mn.

7. The improved low iron aluminum alloy according to claim 5, wherein the alloy is preferably about 0.15 wt. % Fe and 0.55 wt.% Mn.

8. The method of producing an improved low iron cast aluminum alloy product comprising:

providing an alloy comprising about 0.10 to .35 wt. % magnesium, about 8.50 to 11.00 wt. % silicon, about 0.40 to 0.80 wt. % manganese, and with preferably less than 0.50 wt. % iron, the balance substantially aluminum and incidental elements and impurities;

casting a body of said alloy;

heat treating the cast frame component; and

aging said component.

9. The method of producing an improved low iron cast aluminum alloy product according to claim 8, wherein the alloy is preferably about 0.15 to 0.20 wt. % magnesium.

10. The method of producing an improved low iron cast aluminum alloy product according to claim 8, wherein the alloy is preferably about 9.5 to 10.5 wt. % silicon.

11. The method of producing an improved low iron cast aluminum alloy product according to claim 8, wherein the alloy is preferably about 0.5 wt. % to 0.7 wt. %. manganese.

12. The method of producing an improved low iron cast aluminum alloy product according to claim 8, wherein the alloy is preferably between about 0.10 to 0.50 wt.% iron and between about 0.40 to 0.80 wt.% Manganese and the total weight percent of Fe plus Mn is no greater than approximately 0.90 wt. %.

13. The method of producing an improved low iron cast aluminum alloy product according to claim 12, wherein the alloy is preferably about 0.10 wt. % Fe and 0.60 wt.% Mn.

14. The method of producing an improved low iron cast aluminum alloy product according to claim 12, wherein the alloy is preferably about 0.15 wt. % Fe and 0.55 wt.% Mn.

15. The method of producing an improved low iron cast aluminum alloy product according to claim 8, wherein the cast product is a frame member in a vehicle.

16. A product whose production includes the method of claim 8.

17. In the production of a vehicular frame component wherein a cast component is formed by one or more operations into said frame component, the improvement wherein the production of said cast

component includes:

providing an alloy comprising about 0.10 to .35 wt. % magnesium, about 8.50 to 11.00 wt. % silicon, about 0.40 to 0.80 wt. % manganese, and with preferably less than 0.50 wt. % iron, the balance substantially aluminum and incidental elements and impurities;

casting said frame component from said alloy;

heat treating the cast frame component; and

aging said heat treated cast frame component to render said frame component.

18. A vehicle frame comprising cast components that are joined together to make a frame or subframe, at least a plurality of said cast components comprising aluminum alloy comprising about 0.10 to .35 wt. % magnesium, about 8.50 to 11.00 wt. % silicon, about 0.40 to 0.80 wt. % manganese, and with preferably less than 0.50 wt. % iron, the balance substantially aluminum and incidental elements and impurities.

19. The vehicle frame according to claim 18, wherein the alloy is preferably between about 0.10 to 0.50 wt.% Iron and between about 0.40 to 0.80 wt.% manganese and the total weight percent of Fe and Mn is no greater than approximately 0.90 wt. %.

20. The vehicle frame according to claim 18, wherein the alloy is preferably about 0.10 wt. % Fe and 0.60 wt.% Mn.

21. The vehicle frame according to claim 18, wherein the alloy is preferably about 0.15 wt. % Fe and 0.55 wt. % Mn.

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US96/02749

A. CLASSIFICATION OF SUBJECT MATTER

IPC(6) : C22C 21/02
US CL : 148/549, 698, 702, 440; 420/546
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

U.S. : 148/549, 698, 702, 440; 420/546

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X --- Y	Database Chemical Abstract (Columbus, Ohio, USA), AN 91:25685, GB 1529305 A (MORRIS ET AL) , abstract, 18.10.78. abstract	1-7, 17-21 --------------- 8-16
X --- Y	US,A 1,947,121 (BONSACK) 13 February 1934, claim 1	1-7, 17-21 --------------- 8-16
Y	US,A, 4,104,089 (MIKI) 01 August 1978, abstract	8-16

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

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